



Patient-Related and Financial Outcomes Analysis of Conventional Full-Arch Rehabilitation Versus the All-on-4 Concept: A Cohort Study

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The use of osseointegrated dental implants in clinical practice began more than 5 decades ago with the novel work of Brånemark.¹ The initial aim at that time was to provide an aggressive solution for improving the quality of life of fully edentulous patients. Dental implants have become the premier choice among other treatment alternatives for replacement of missing teeth in contemporary clinical practice. Even though various treatment approaches are available for the restoration of partially edentulous patients, the restoration of fully edentulous jaws has been revolutionized, thanks to the introduction of implant-supported restorations.² The high success and survival rate of implants has given a significance impetus to their mainstream use in clinical practice. Selection among the various approaches available for

Background: Patient-related variables such as cost of treatment, length of the treatment period, and comfort provided by the interim prosthesis when treatment planning for full-arch rehabilitation are often neglected in dental publications.

Methods: Two patient cohorts were followed up longitudinally in this study: the “All-on-4 treatment concept group” and the “historical group.” The number of implants, total treatment time, number of surgical procedures, number of sinus grafts, necessity for immediate provisional implants, adjusted cost associated for treatment in each group, and the quality of interim prosthesis were compared.

Results: The total adjusted cost for patients receiving All-on-4 treatment concept averaged at \$42,422 ± 3860 (€31,392 ± 2856), whereas the

mean total adjusted cost for the historical group was \$57,944 ± 20,198 (€42,879 ± 2113) (P = 0.01). The difference in cost had a mean value of \$7307 (€5407) per jaw. Factors associated with complexity of treatment and patient comfort, such as the quality of interim prosthesis, number of surgeries, and duration of treatment time, all significantly favored the All-on-4 treatment concept group in comparison with conventional treatment modalities.

Conclusions: When implant rehabilitation of the total jaw is sought, the All-on-4 treatment concept should be considered the least costly and least time consuming treatment option. (*Implant Dent* 2014;23:218–224)

Key Words: finances, patient related, all-on-4 treatment concept, dental implants

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the rehabilitation of complete edentulism has been further challenged under the light of recent advances such as the All-on-4 (All-on-4; Nobel Biocare, Göteborg, Sweden) treatment concept.³ The All-on-4 treatment concept has initiated a transition from a mechanical approach for implant dentistry to a new era where treatment planning is based on biomechanics and function, esthetics, and overall quality of life.

Maló et al^{3,4} used bioengineering principals to pioneer the All-on-4 treatment concept and suggested that the placement of 4 implants in strategic positions in an edentulous jaw can provide adequate support for the immediate loading of a fixed restoration. Use of this innovative treatment planning approach permits immediate loading with a fixed provisional restoration. At 3 to 4 months,

fabrication of a fixed definitive prosthesis is initiated.^{5,6}

Initially, there was significant skepticism regarding this approach based on knowledge from *in silico* analysis that angled abutments or /implants are associated with higher stress in the bone.⁷ However, more elaborate protocol-specific models were developed that verified the feasibility of placing 2 straight and 2 tilted implants and found the support for the fixed prosthesis to be equal or superior to conventional concepts.⁸⁻¹⁰ Subsequently, the engineering principle that dictated the use of as many straight implants as possible in a jaw begun to decrease with the introduction of new evidence.

Over the last decade, there has also been an increase in the volume of scientific evidence documenting the clinical performance of the All-on-4 treatment concept, which has enhanced its' widespread clinical use. Following the report of longitudinal data by Malo et al,¹¹ several other authors have verified the high success rates associated with the use of this protocol, such as Galindo and Butura¹² In their study, 857 implants were placed as 2 pairs per jaw according to the All-on-4 treatment concept. After 3 years of follow-up, only 3 implants failed.¹²

Babbush et al⁵ reported a 99.6% cumulative survival rate with follow-up of up to 29-months for 708 implants placed in complex cases including immediate implant placement and immediate loading using the same concept.

In even wider studies, Babbush and Brokloff¹³ and Graves et al¹⁴ have reported results from 1001 and 1110 implants, respectively, which were placed with the same protocol. Their outcomes further supported the success rates reported in the previous studies. The clinical success of the All-on-4 treatment concept is well documented in the literature, and it is considered to be a predictable technique with a very good prognosis.¹⁵

Additional studies that have demonstrated the impact of the All-on-4 treatment concept on the quality of life of these patients have concluded that majority of them is highly satisfied with this type of treatment, even more so thanks to the immediate-fixed provisional prosthesis.^{16,17}

Despite the previously cited benefits of the All-on-4 treatment concept, implant treatment planning is still largely approached on an empirical basis in accordance with the familiarity of the surgeon and the restorative dentist with a specific technique. Patient-related variables such as cost of treatment, the length of treatment, and comfort provided by the interim prosthesis during the transition from the surgical insertion phase until delivery of the final prosthesis are often neglected in clinical research. The application of results of studies on the clinical performance of the All-on-4 treatment concept has been hindered by the lack of evaluation of factors other than purely clinically related variables, such as implant success or prosthesis survival. The missing part of the equation may be the answer to the question whether the All-on-4 treatment concept provides a substantial financial benefit when compared with conventional full-mouth implant rehabilitation strategies.

The aim of this retrospective cohort study was to evaluate patient-related financial outcomes of treatment between a cohort of patients treated with traditional approaches for the rehabilitation of the complete jaw versus a cohort of patients treated with the All-on-4 treatment concept. Secondary outcomes such as the number of surgeries, the duration of treatment, and the quality of the interim restoration (removable vs fixed) were also evaluated to assess the complexity of each treatment approach from a patient's perspective. Results of this study may encourage clinicians to include a patient-related perspective in their decision-making philosophy when planning treatment for the implant rehabilitation of the total jaw.

MATERIALS AND METHODS

Two patient cohorts were randomly selected following chart review of the records of a single private practice and were followed up longitudinally in this study: the All-on-4 treatment concept and the "historical (HIS) group." All patients were surgically treated in the same private practice by one of the authors (C.A.B.), a board-certified, oral and maxillofacial surgeon, with extensive

experience in implant reconstruction since 1968. All patients consented to the proposed treatment plan at the time of treatment.

The HIS group consisted of patients who underwent treatment between January 1991 and October 2008 using conventional implant treatment-planning approaches.² Treatment alternatives included full-arch fixed restorations on natural dentition, implant-supported overdentures, or fixed full-arch implant-supported restorations on at least 6 implants per jaw (HIS group) (Figs. 1 and 2).

Patients in the "All-on-4 treatment concept" (AOF) group underwent treatment using the All-on-4 treatment concept³ from September 2008 to October 2010 (Figs. 3 and 4).

Inclusion criteria:

- Patients requiring complete rehabilitation of the maxilla and the mandible.
- Completed treatment with full-arch fixed restorations on natural dentition, implant-supported overdentures, fixed implant-supported restorations on at least 6 implants per jaw (HIS group), or fixed screw retained restorations on 4 implants per jaw (AOF).

Exclusion criteria: inadequate financial data, patients who had received discounts, patients electing to tolerate removable partial dentures, and patients with unrestored natural teeth.

Demographic data, the number of extractions, the number of implants placed, necessity for sinus augmentation, type of final prosthesis, and follow-up time were recorded for patients in each cohort. The number of surgical interventions and the type of interim restoration were also evaluated as factors associated with the patients' well-being. Fewer surgical interventions were considered as providing increased patient satisfaction in comparison with a greater number of surgical interventions.

The types of interim restorations employed were fixed screw-retained, fixed cemented-retained, fixed teeth-supported, full denture, or no provisional prosthesis. Interim restoration alternatives were categorized according to their

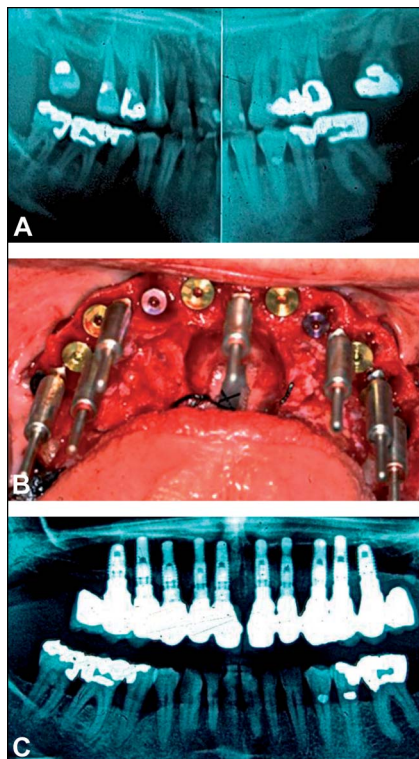


Fig. 1. **A**, Preoperative radiographic image of a 47-year-old patient who presented with a hopeless maxillary dentition. **B**, Intraoperative view showing the placement of immediate provisional implants in the edentulous sites between the standard implants to allow for delivery of a fixed provisional restoration and allow for undisturbed healing of the implants based on conventional treatment planning principles. **C**, Postloading panoramic radiograph showing good bone levels around the loaded implants, at 36 months postoperatively. (Compare Figs. 1 and 2 with Figs. 3 and 4.)

impact on quality of life as reported by Babbush¹⁶ and Brennan et al.¹⁸

Two “quality gradients” for interim prostheses were assigned according to the following assumption: fixed provisional restorations either on teeth, or implants were considered as satisfactory (grade A), whereas interim full dentures or no provisional restorations were considered as compromised alternatives (grade B).

Patients were followed up for at least 2 years postloading for evaluation of implant success according to the criteria of Buser et al¹⁹ Briefly, the absence of subjective symptoms, active periimplant disease, and mobility were assessed clinically when radiographic examination was performed during

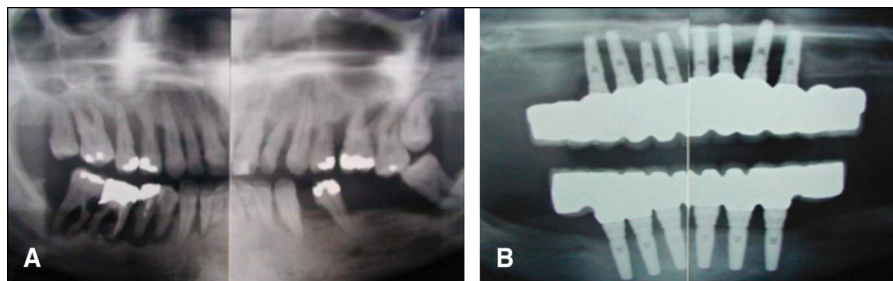


Fig. 2. **A**, Radiographic view of the oral condition of a 44-year-old patient who presented for an implant consult. Note the extensive loss of alveolar bone because of severe periodontal disease. **B**, The patient restored with fixed prostheses in both jaws, after placement of 8 and 6 implants in the upper and lower jaw, respectively, based on the principles of conventional implant treatment planning, as demonstrated in this 36-month panoramic radiograph.

routine follow-ups to verify the absence of pathology and/or bone loss around the implant.

Financial Analysis

Both patient cohorts were followed up until placement of definitive restorations for estimation of treatment expenses. Direct costs for each intervention were retrieved from patients’ financial records and were adjusted using the 2013 version of a specialized software (CPI Inflation calculator; Bureau of Labor statistics, US department of Labor), which reflects the current value of money of a specific amount of finances spent during a previous year, based on the data from the Bureau of Labor statistics. All treatment costs were adjusted to June 2013 prices before statistical analysis. The analysis was performed from a patient’s perspective. The surgical fee and prosthetic fee were combined to calculate total expenses per patient incurred during treatment of each jaw. The cost per arch ratio (CPAR) was estimated for each patient cohort after adding the implant and prosthesis cumulative costs for each patient in the cohort, dividing it by the number of patients and further dividing by 2. The CPAR was used as a direct measure of value for money for each cohort. Based on 2013 currency exchange average, an exchange rate of 0.74 was used to estimate the US dollar to Euro conversions.

Statistical Analysis

Demographic data and data associated with type of treatment and finances were reported descriptively using mean or median as a measure of central

tendency and SD or range as a measure of variance when indicated. An unpaired *t* test, or a Mann-Whitney *U* test was used to compare the number of implants, total treatment time, the number of surgical procedures, the number of sinus grafts, necessity for immediate provisional implants, and adjusted cost associated for treatment in each group depending on results of a Shapiro-Wilk normality test for each variable. Data on the quality of interim prosthesis were treated as ordinal data, and a Mann-Whitney ranked test was used for assessing the difference on the quality of the interim prostheses between the 2 groups.

An application specific software was used for statistical analysis, and the threshold for significance was set at $P < 0.05$.²⁰

RESULTS

Both cohorts had similar baseline characteristics with the historical consisting of 15 patients (6 men and 9 women; mean age at baseline, 55 years; range, 15–81 years) and the All-on-4 treatment concept consisting of the same number of patients (9 men and 6 women), with a mean age of 62 years at baseline (range, 46–82 years). Age and gender were not significantly different at baseline between the 2 groups ($P = 0.065$ and $P = 0.29$, respectively). Patients in the AOF group required an average of 6.87 ± 4.41 extractions in the maxilla and 8.73 ± 3.71 in the mandible, whereas patients in the “traditional” group required 6.93 ± 4.46 in the maxilla and 5.40 ± 5.51 in the

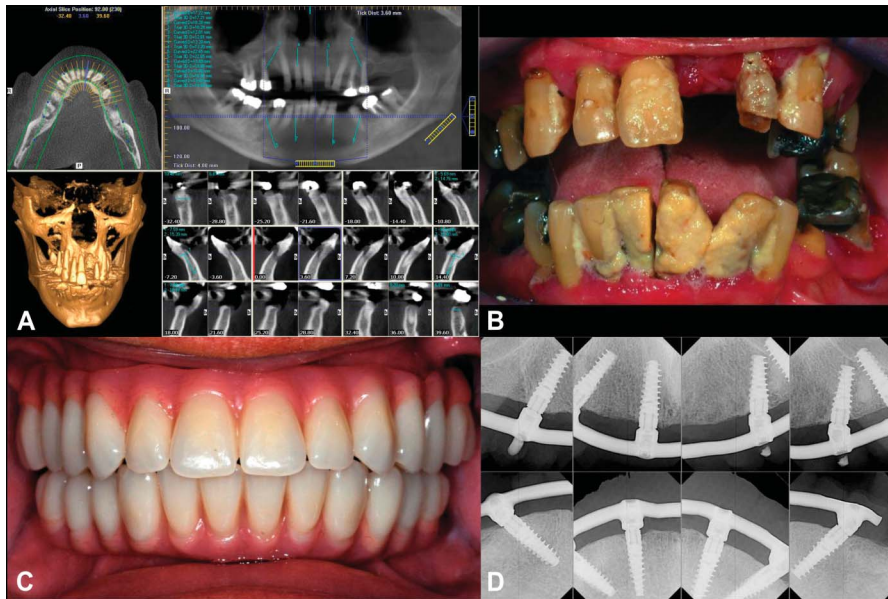


Fig. 3. **A** and **B**, Clinical and radiographic images showing the preoperative condition of a 62-year-old patient for whom treatment with the placement of 4 implants in each jaw to support fixed restorations was planned. **C** and **D**, Postoperative clinical and radiographic views of the same patient who was treated according to the All-on-4 treatment concept, at 24 months postloading.

mandible. No significant difference was identified between the 2 groups. Treatment characteristics for patients of both groups are presented in Table 1.

All patients in the AOF group were treated using NobelActive (Nobel Biocare) implants. More heterogeneity was observed in the HIS group with

IMZ (Friedrichsfeld AG, Mannheim, Germany), Nobel Replace (Nobel Biocare), Replace Select (Nobel Biocare), Steri-oss (Steri-Oss, Yorba Linda, CA), Camlog (CAMLOG Biotechnologies AG, Basel, Switzerland), and NobelActive (Nobel Biocare) implants being used. Patients in the AOF group had significantly less implants placed and needed no adjunctive sinus augmentation procedures or immediate provisional implants to support interim prostheses.

Restorations in both groups of patients remained functional throughout the observation period for a 100% prosthesis survival rate in each group. In the AOF group, 1 NobelActive implant failed before delivery of the final prosthesis and was replaced and incorporated into the prosthesis with no further complications or failure. The implant cumulative survival rate at the end of the follow-up was 99.17% (119/120). In the HIS group, 2 patients experienced implant failure. In 1 patient who had 10 implants placed in the maxilla, 1 was not osseointegrated at the second-stage surgery. The remaining 9 implants were deemed adequate to support a fixed restoration, and the implant was not replaced. In another patient, 2 implants fractured after the patient reported being involved in a “fist-fight.” They were each replaced at stage 2 surgery and were loaded with no further complications.

Differences between groups were identified in the mean follow-up time that was 41.32 ± 10.19 months in the AOF group and 139.40 ± 61.57 in the HIS group. This difference is attributed to the transition of this clinic setting toward the use of the All-on-4 treatment concept in recent years.

Patient-Related Financial Outcomes

The use of a specialized inflation calculator software allowed to estimate the mean total cost for each treatment modality based on June 2013 values. The total cost for patients receiving the All-on-4 treatment concept averaged at $\$42,422 \pm 3860$ ($\text{€}31,392 \pm 2856$), whereas the mean total cost for the HIS group was $\$57,944 \pm 20,198$ ($\text{€}42,879 \pm 2113$). The maximum in each group was $\$47,987$ ($\text{€}35,510$) and $\$89,961$ ($\text{€}66,571$), respectively.

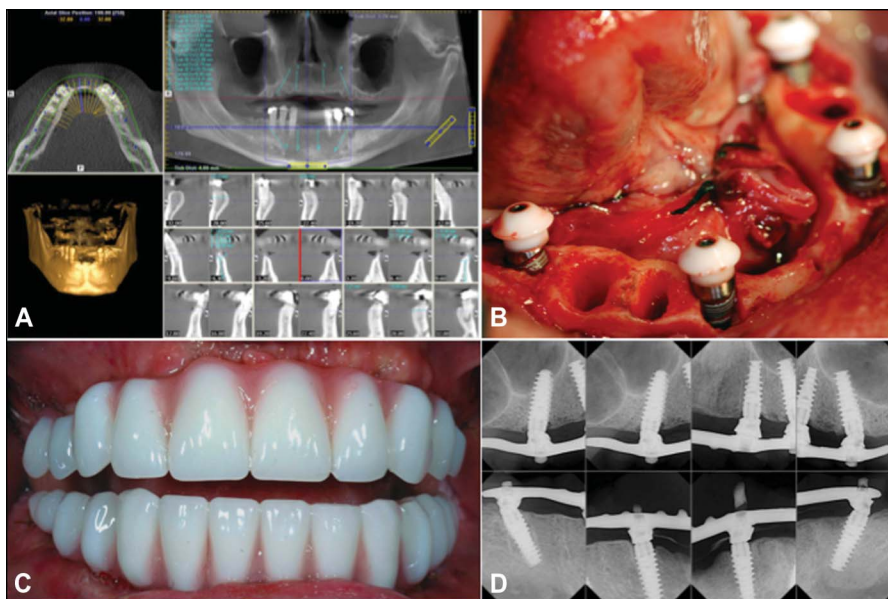


Fig. 4. **A**, Baseline CBCT cross-sections showing the preoperative condition of a 48-year-old patient who was scheduled to undergo implant treatment based on the All-on-4 treatment concept. The green lines show the desired implant locations. **B**, Intraoperative view of the anterior implants that have been placed straight and the posterior ones that are tilted. **C**, Clinical view of the fixed provisional restorations that were immediately loaded. **D**, Radiographic image taken at 36 months postloading. Note the very good maintenance of bone levels around both the straight and tilted implants.

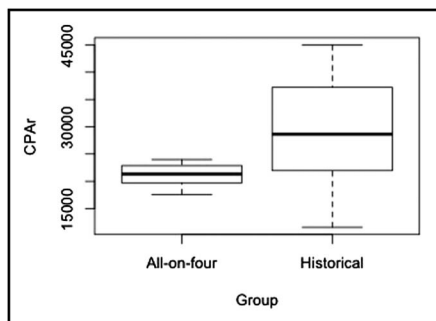


Fig. 5. The boxplots outline the distribution of CPAr values in each group. The bold black line represents the median of each group, whereas the base of each box represents the 25th percentile and the top of the box the 75th percentile. Note that values in the AOF group are distributed closely around the median, whereas a much greater range of prices is noted in the HIS group.

Statistical analysis revealed that treatment in the HIS group was significantly more expensive ($P = 0.01$).

The median CPAr in the AOF group was \$21,328 (€15,783) for rehabilitation of 1 arch, whereas the HIS group had a median of \$28,635 (€21,190), for a difference of \$7307 (€5407) per jaw that yielded the AOF concept group statistically significant less costly ($P = 0.01$). Comparison of CPAr between groups revealed that the majority of CPAr values in the AOF group were within the lowest quarter percentile of the HIS group (Fig. 5).

Patient-Related “Well-Being” Outcomes

During the postimplant placement healing period, all patients in the AOF

group were restored with “A” quality provisional restorations in both jaws. In the HIS group, “B” quality restorations were delivered in the maxilla of 10 of 15 patients (66.6%), all of which were immediate complete dentures. In the mandible, 3 patients were provisionally restored with immediate complete dentures, and 1 patient elected to proceed with no provisional denture; the remaining patients (11/15) received fixed interim restorations (Fig. 6).

In the HIS group, an average of 2.7 ± 0.8 surgeries were required for the total rehabilitation of both jaws, whereas a single surgical intervention was performed in all cases in the All-on-4 treatment concept. Statistical analysis revealed that a significantly lower number of surgeries is required for patients undergoing treatment with the All-on-4 treatment concept protocol ($P < 0.001$).

DISCUSSION

In this study, we longitudinally followed up 2 cohorts of patients. The most relevant finding was that the cost of treatment per jaw was significantly less in the AOF group in comparison with the HIS group. The difference was approximately \$7300 (€5400), which can be translated to \$14,600 (€10,800) for patients that require maxillary and mandibular prostheses.

It has been well documented that the All-on-4 treatment concept in full-arch reconstruction is a viable long-term treatment modality.^{11,21-23}

Most current results from a large patient pool have shown that the prostheses’ survival rate for the All-on-4 treatment concept cases is 99.2% with up to 10 years of follow-up, whereas the implant success rate is as high as 94.8%.¹¹

Undoubtedly, clinical success and finances are 2 pivotal factors in patients’ decision-making process to accept or reject a proposed treatment plan.²⁴⁻²⁸ Our study also included outcomes from the assessment of quality of life during treatment. The quality of interim prosthesis in each patient was selected as an appropriate surrogate for the patient’s quality of comfort during the transitional phase from the time of extractions until the delivery of the definitive prosthesis. It is well documented that

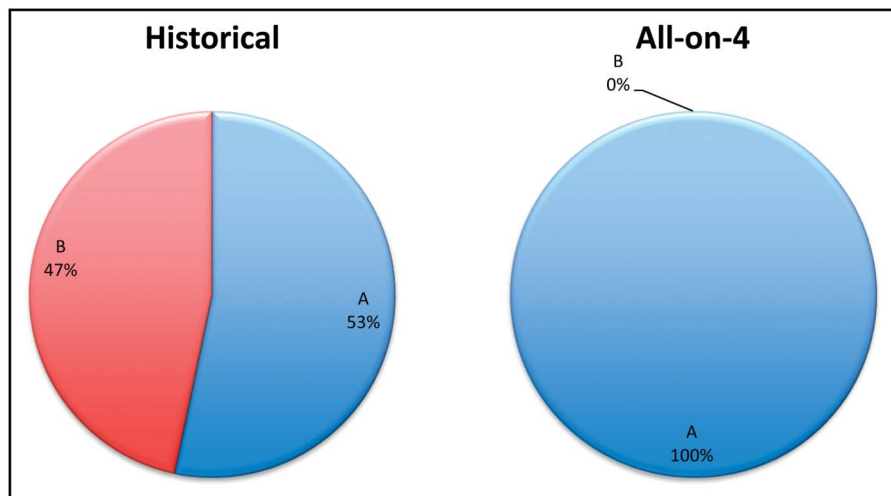


Fig. 6. Results from the evaluation of “quality” of interim restorations between the 2 groups on patient level. Forty-seven percent of patients in the HIS group had a “B” quality interim prosthesis in at least 1 jaw, whereas 100% patients in the AOF group were provided with fixed screw-retained restorations during the initial healing period ($P < 0.001$).

Table 1. Intergroup Comparison of Surgical Treatment Characteristics Between Groups				
	Group	Mean	SD	P*
No. implants (maxilla)	All-on-4	4	0	<0.001†
	Historical	8.33	1.68	
No. implants (mandible)	All-on-4	4	0	0.003†
	Historical	5.2	2.99	
Sinus grafts	All-on-4	0	0	0.035‡
	Historical	0.53	0.92	
Provisional mini implants	All-on-4	0	0	0.073
	Historical	1	2	
Total treatment time (mo)	All-on-4	9.33	3.96	<0.001†
	Historical	20.27	9.65	

*Mann-Whitney U test.
 † $P < 0.001$, statistically highly significant.
 ‡ $P < 0.05$, statistically significant.
 The results from the All-on-4 group are given in boldface.

removable dentures yield significantly less patient satisfaction in comparison with fixed restorations and are associated with unsatisfactory masticatory ability and have a negative effect on the persons' social life.²⁹⁻³¹

Comparison of the AOF and the HIS cohort showed that the quality of interim prosthesis was statistically significant better in the AOF group. Forty-seven percent of subjects in the HIS group could not have a fixed interim prosthesis based on conventional treatment planning.

Babbush¹⁶ was the first to discuss the patient related-aspects of treatment using the All-on-4 treatment concept. The results showed that 95% patients were satisfied with their experience after treatment, with 74% patients describing themselves as extremely satisfied. These findings point out that the economics for the patient is not the only benefit associated with the All-on-4 treatment concept approach.

The All-on-4 treatment concept is based on a fundamentally patient-oriented rationale for the rehabilitation of total jaws. It is a result of the optimization of 4 factors: function, biomechanics, affordability, and patient comfort.

The 2 latter factors had not been compared with traditional implant treatment planning until now. The difference in the mean cost per jaw that we identified was approximately 25.5% relative to the mean cost per arch for the HIS cohort. This is a significant financial benefit for a patient that is already called to allocate a large amount of funds. In addition, the results showed a difference in the number of surgical interventions as 2.7-fold and total treatment time as 2.1-fold, in the HIS group in comparison with the AOF.

The findings of this study aim to provide clinicians with a broader perspective for treatment planning for full-arch rehabilitation. When treatment alternatives are discussed with patients, it is important to address such factors as duration of treatment, patient quality of life during treatment, and finances, in addition to clinical success including survival of the prosthesis and individual implants. The All-on-4 treatment concept was found to be significantly better than conventional

treatment in regard to all the financial and patient-related outcomes investigated in this study.

CONCLUSION

The financial analysis revealed a highly significant decrease in cost for the All-on-4 treatment concept compared with the corresponding cost of using a conventional implant treatment planning approach. The difference in cost had a mean value of \$7307 (€5407) per jaw. It can be concluded that, when implant rehabilitation of an edentulous arch is sought, the All-on-4 treatment concept should be considered the least costly treatment option.

Factors associated with complexity of treatment and patient comfort, such as the quality of interim prosthesis, the number of surgeries, and duration of treatment time all significantly favor the All-on-4 treatment concept in comparison with conventional treatment modalities.

DISCLOSURE

Dr. Babbush states that he has an ongoing consultancy with Nobel Bio-Care and that he has grants and payment for lectures with this company. All other authors claim to have no financial interests, either directly or indirectly, in the products or information listed in the article.

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